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AUTHOR Nilssen, Vivi; And Others
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ABSTRACT

An analysis of a student teacher's lesson in multiplication for Norwegian second graders explored why the lesson did not succeed. Two interpretive frameworks were used to analyze the lesson: teaching as a complex cognitive activity and teaching as improvisation. The student teacher, Marte, believed in child-centered education and tried to create situations in the classroom where her children experienced success. The analysis of student and teacher exchanges showed that Marte's class derailed because her pupils offered unexpected types of comments for which she was not prepared; she used the dialogue teaching method which created an unstable and unpredictable classroom environment; and in her responses to the unexpected answers she attended to the wrong things. She was also derailed due to lack of pedagogical content knowledge in mathematics. She was unable to interpret her pupils' answers so that she could understand the kind of mathematical reasoning that produced these answers. This limited her ability to generate appropriate mathematical representations on the spot. In the next lesson, after reflecting on the first presentation, Marte reduced lesson complexity, made the lesson more structured and orderly and so was able to maintain control, improve her teaching, and still use the dialogue method. (Contains 25 references.) (JB)

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UNEXPECTED ANSWERS

Case study of a student teacher derailing in a math lesson

Vivi Nilssen
Høgskolen i Sør-Trøndelag, avdeling for lærerutdanning
and Åsvang skole, Trondheim

Sigrun Gudmundsdottir
University of Trondheim

Vibeke Wangsmo-Cappelen
Bruråk skole, Trondheim

Norway

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UNEXPECTED ANSWERS: CASE STUDY OF A STUDENT TEACHER DERAILING IN A MATH LESSON

This paper describes in details how a student teacher derails in when teaching second graders multiplication. She has all the right ideas from her teacher education: she beliefs in child-centered educationm she wants to create situations in the classroom where her children "experience success." Yet, she derails because her pupils comments are unexpected. She uses the dialogue as a teaching method, which creates an unstable and unpredictable classroom environment. In her responses to the unexpected answers she attends to the wrong things, like not wanting to "hurt" her pupils by saying they are wrong, overriding the interests' of rest of the class who hear the wrong answer. She gets easily derailed due to lack of pedagogical content knowledge in math. She is unable to interpret her pupils answers so that she can understand the kind or mathematical reasoning that produced these unexpected answers. This limits her ability to generate appropriate mathematical representations on the spot. Two interpretative frameworks are used in data analysis: Teaching as a complex cognitive activity and teaching as improvisation.

UNEXPECTED ANSWERS: CASE STUDY OF A STUDENT TEACHER DERAILING IN A MATH LESSON

Teacher education in many Western countries promotes child-centered primary-school education. This often it means that the pedagogic strategies focused on are consistent with the spirit of open education. In practice this results in a classroom that promotes the growth of the whole child. When child-centered education functions well, it can be the best possible education for young children. When it does not work well it can have unfortunate consequences (Bennett 1975). Student teachers experience open classrooms both as complex and multidimensional (Doyle 1977). They have problems keeping an eye on many things and keeping several activities going all at the same time. The consequence is that all too often things do not go as planned. This paper describes and analyses how a student teacher experiences an open classroom, with all its complexities and multidimensionality. "Marte" is a student teacher who has been thoroughly socialized in child-centered education through her teacher training. She wants to promote the "whole child" and she wants to create situations in the classroom where the students "experience success." She puts the child at the center of her careful lessons preparations and she expresses concern for "activity" and "experience" in her curriculum planning. She uses dialogue as a teaching method in all her classes.

The dialogue method is practised by all child-centered educators. It goes by several names, such as "interactive teaching" and "conversations with the class." At the heart of this teaching method is a substantial contribution from the children to the development and progress of teachers' explanations. In the hands of veteran child-centered educators it looks like orderly and effortless. It is, however, one of the most difficult teaching methods used in the primary school, especially because of the uncertainty it can create in the classroom. In Scandinavia, Høines (1987) has developed a teaching strategy for math based on the dialogue method. The essence of this strategy is that children solve problems using their knowledge and experiences, that is, they develop their own strategies for solving math problems. For example:

Teacher:	*Lars has three slices. Write down how many? Bente has two slices. Write down how many? Who has more? Can you figure out a way to write "more."*
Child 1:	*I circle the bigger number.*
Child 2:	*I color the bigger number red.*
Child 3:	*I cross the bigger number.*
Child 4:	*I underline the bigger number.*
Teacher:	*How do you know which is someone else's bigger number?*

The teacher's last question requires the children to explain their strategies. All the strategies the children have invented are accepted. The children are required to communicate their strategies to each other and to the class, and

they will gradually come to understand the need for a "common" way to express "more" with a mathematical symbol.

No great pedagogical insight is needed to realize that this is a good teaching strategy, when it works. It works when teachers command both solid general pedagogical knowledge and pedagogical content knowledge in math (Shulman 1987). Many experienced teachers have such a background and descriptions of their teaching are found in various publications (see for example descriptions by Ball 1990a, 1990b, 1991, 1994, Borko and Livingston 1989, Lambert 1985a, 1985b, Leinhardt and Smith 1985).

The dialogue method is difficult for student teachers because they find it impossible to predict what 25 children will think and say when asked. Even though student teachers prepare well for the classes they teach, they are easily derailed by unexpected answers. This is especially apparent in the teaching of mathematics where student teachers lack both mathematical knowledge and pedagogical content knowledge in math. It is not enough to master the social aspects of classrooms as manifested in general pedagogical knowledge. The substantial, as manifested in pedagogical content knowledge, is also important if the children are going to learn math in a mathematically sound way. Our student teacher, Marte, in spite of solid preparation for her math lessons is derailed in her lessons (to a much lesser degree towards the end of her teaching-practice period). To describe the process of derailing, we

will focus on only one lesson. This lesson as a whole captures the essence of what happens when Marte is derailed by unexpected answers or comments by the children.

Defining the unexpected comments that lead to derailing

Unexpected comments are comments from the children that are different from what Marte was expecting and subsequently lead to the derailing of her plans. In a reflection over a video recording of the lesson (where she introduced multiplication) she describes how she was caught off guard[1]:

> *They begin with ten plus ten. They think so differently that I do (video interview 01/26/94, page 5).*

The event she is commenting on occurs shen she is trying to show the children that multiplication is something useful when they are dealing with many numbers. She selects five children from the group (the rest are sitting on the carpet), and asks them to raise their hands and show all their fingers. She wants to demonstrate that five plus five ten times equals fifty. The children, however, only mention ten. After all, they know they have ten fingers!

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[1] Marte commented, when watching a video recording of this episode, that it was this incident that initiated the derailing of her plans. Marte, like the children in her class, speaks the local dialect called Trøndersk. The original version Norwegian version of this paper has her words written in Trøndersk, while the maia body is written in standard Norwegain. Trøndersk, spoken and written, is very different from standard Norwegian. •

These unexpected comments come about because Marte's lesson plans include the dialogue method. Sometimes these comments, whether mathematically wrong or correct, are different than what she expects. In the episode above she asks questions which a child answers. She has asked: "How many fingers do five children have?" They answer, of course: "Ten fingers each." Marte had not expected such an answer, indeed she had planned that they would answer "five fingers on each hand." Other times there are uninvited shouts from the children that Marte feels she has to respond to. The unexpected comments eventually lead to a derailing of Marte's plans and she frequently finds herself in a situation where she is not in control of the class (Nilssen 1995).

Theoretical framework

Two kinds of theoretical framework are relevant for understanding the dialogue method as used in the classrooms by student teachers: teaching as a complex cognitive activity and teaching as improvisation (Borko and Livingstone 1989). Three processes have been identified that make teaching a complex cognitive activity; multidimensionality, simultaneity and unpredictability (Doyle 1977). Classrooms are multidimensional because there are conflicting demands and aims. They include a series of events that are not always consistent with each other. The children, for example, are

different in terms of motivation and background. They have different aims and behave differently. Furthermore, teachers need to keep several activities going at the same time: teach multiplication, diagnose children's responses, lead the class dialogue, cope with emotional responses to events in the classroom, establish and maintain routines, distribute materials and so on. Moreover, all these interact in a way that makes the events in one area influence those in another.

In addition to being multidimensional, classrooms are simultaneous, that is many things occur at the same time. The teacher must keep track of the interaction as a whole. While focusing on a child's response, she must at the same time be fair in terms of turn taking, while all the time evaluating each child's answer in regard to the relevance to the topic. The simultaneity of classroom events and the chances of events occurring contribute to unpredictability. Student teachers are especially affected by these dimensions. They find it difficult to predict what the children's responses will be or anticipate how long each activity will last. They are also frustrated by frequent interruptions that are a simple fact of life in the early grades, and they are not skillful in adapting plans as classroom events unfold. This complex situation in classrooms enhances a feeling of insecurity among many student teachers.

There are activities with less complex structures. Drill and practice are activities that create order, but only on the surface. In the mind of the children there might well rage a quiet chaos as the children may not understand what they are doing. A lesson that includes sequences that are cognitively complex involves a higher level of multidimensionality, simultaneity and unpredictability. Questions with many right answers enhance the cognitive complexity of learning environments. The direction of the dialogue becomes less predictable and teachers have to engage in a complex evaluation process in interpreting children's answers. Moreover, children's answers to complicated questions tend to be longer and more complex than in situations where there is only one right answer. In short, it requires more skill to maintain the pace of a cognitively activity that to initiate it.

As they gain more teaching experience, student teachers develop strategies to reduce the complexities of the classrooms. Doyle (1977) discerned that the successful students were able to transform the complexities into a system of operational concepts that enabled them to reflect and analyze events and later to control the direction of the lesson. Furthermore, they were quickly able to interpret events and accurately predict the consequences of events. Moreover, the successful students were able to distribute their attention more evenly to include many things happening at the same time.

The less successful students had a tendency to give directions and continue as if the directions had been understood and were being followed by the children, when they were indeed not.

One of the reasons why teachers plan is to reduce the complexity of classrooms. A plan is primarily a psychological process in which the future is being visualized and predicted to a certain degree (Clark and Yinger 1987). The planners create a frame in which to govern their future activities, but teaching happens as discussed above, in relatively unstructured, dynamic and shifting environments. It can never (nor should it) be fully controlled by teachers' actions. The construction of plans together with the skill to make quick decisions in action makes teaching a complex cognitive activity (Leinhardt and Greeno 1986).

Effective teaching is based on two fundamental knowledge structures; lesson structure and content knowledge (Leinhardt et. al 1991). Lesson structures are concerned with the planning the curriculum and carrying out the plans in a lesson. This involves automatic routines for interactions with students, the coordination of different aspects of the lesson, and also the ability to see the whole simultaneously. Content knowledge is concerned with the knowledge a teacher must have to teach a subject in a particular grade. This does not mean that it requires advanced calculus to teach second grade math. It means, instead, that a different kind of mathematical

knowledge is required, one that is fundamentally different. It requires principled knowledge of mathematical concepts and knowledge of ways to present and represent mathematical knowledge that will lead to understanding. It includes understanding how students think and reason mathematically, what knowledge and misconceptions students bring to the learning context and how to diagnose these (Ball 1988, 1990c, Høines 1987, Lampert 1986, Leinhardt et. al 1991). Effective teaching is dependent upon many types of knowledge that is put into action in a relatively dynamic and unstructured environment. Effectiveness in an area is further dependent upon easy and flexible access to well organized and effective knowledge structures. It is difficult to put a plan into action in the classroom, studies of student teachers show that. Unexpected events keep occuring and eventually derail the student. Somehow, experienced teachers manage this. The explanation is that they have better developed knowledge structures to draw upon in these situations (Borko and Livingstone 1989). Carter (1986) agrees, and suggest further that experienced teachers have a larger knowledge base to draw on when planning for the unexpected.

Effective teachers have complex knowledge structures that combine different organized actions. Leinhardt and Greeno (1986) call these schema and use in their analysis of teaching as complex cognitive skill. One characteristic of effective teaching is that many single actions are effortlessly

performed because they have been thoroughly routinized through many years of practice. Effective teachers often have a large repertoire of such effortless and automatic routines. They are important in all effective teaching because they reduce the cognitive complexity of the teaching situation, and teachers are "free" to attend to the unanticipated. Another schema for teaching includes structures that Leinhardt and Greeno (1986) call information schema. This schema makes it possible for teachers to deal with teaching situations that deal with interactions between different goals and activities, a considerable source for difficulties in cognitively complex situations.

If teachers are to be effective, they need effective schemas that are available during the lesson. Shavelson (1986, cited in Borko and Livingston 1989) describes two types of schema that he suggests are the foundation of teacher knowledge: script, scenes and propositional structures. Script is a knowledge structure that includes information about every day activities. Experienced teachers have script for regular and routine activities in the classroom such as checking homework, presenting new information, helping and carrying on a conversation with the whole class. These become automatic after a while and can be observed as "routines." Effective teachers integrate these "routines" into a meaningful whole that is the lesson. Their large repertoire of scripts is constantly being updated and revised as they gain more experience. When teachers plan, they do so in the areas they need to

plan, but much teacher knowledge is already automatic routines. Scenes represent knowledge about people and objects involved in classroom interactions such as whole-class teaching, group-work and individualized learning. Propositional structures include teachers' knowledge about components in the teaching/learning process, such as their pupils, their classrooms, the subjects they teach and their teaching methods. Many of the differences between experienced and novice teachers can be accounted for through these three concepts: schema, script and propositional structures. Experienced teachers have more sophisticated, more complex and more integrated schema than novice teachers. These are also more accessible in action. This gives experienced teachers instant access to bigger and better reservoir of facts, principles and experiences as they plan, act, reflect or engage in other types of pedagogical reasoning. The necessary propositional structures for pedagogical content knowledge are almost non-existent in the knowledge base of novices (Borko and Livingston 1989). Pedagogical content knowledge, claim Shulman (1987), is unique for the teaching profession. It includes knowledge of content and pedagogy, together with an understanding of how topics, problems or ideas are organized, represented and applied in relation to different interests and abilities among students.

When teachers plan, they integrate knowledge from script, scenes and propositional structures to create a lesson agenda that meets the needs of their

class (Leinhardt et. al 1991). This plan functions like an agenda for that lesson. The key elements in the agenda are accessible as teachers' mental notes for the lesson. The agenda serves not just to set up and coordinate the lesson, but does the groundwork for the mathematical concept that is going to be covered in the lesson. The explanations are developed from a system of goals and actions that teachers have to make sure students have understood. The teaching plans are dynamic whereby the different elements are adjusted and adapted as they progress. Another important part of teaching plans is the curriculum script (Leinhardt et. al 1991). This type of script refers to goals and actions for a particular theme. The curriculum script is flesible because classrooms are characterized by interactions. As they follow their curriculum script, teachers must check if the concepts are understood enough to be developed. If students are not responding as expected, experienced teachers will adjust. Without such a robust curriculum script teachers will experience events as unexpected and their plans will de-rail.

Teaching as an improvised performance: It is the lack of well developed pedagogical content knowledge that makes pupils comments "unexpected." While certain lesson events may well be un-planned, they are not quite unexpected because experienced teachers have the necessary knowledge base to deal with it, just like a jazz musicians improvising on the basis of solid knowledge of relevant musical compositions (Yinger 1989).

Actors improvise too. Instead of a detailed script, they enter the scene with a general definition of the situation and a set of guidelines for performance. They draw upon a rich repertoire of routines and action patterns that they weave together with signals from the audience into a spontaneous performance. Yinger (1987) suggests that improvised performance may be a useful metaphor in understanding interactive teaching methods, such as the dialogue method. When teachers improvises, they begin with an outline of the activity. Details are filled in as the lesson progresses and teachers respond to students. Experienced teachers prepare such an improvisation by making their plans flexible so that they can capture unexpected comments and actions from students.

Novice teachers run into problems when they encounter unexpected answers and they have to explain things they had not planned. This happens in spite of careful, consistent and clear lesson plans (Borko and Livingstone 1989). While experienced teachers have a repertoire of explanations, demonstrations and examples that they draw upon to communicate the subject matter to their pupils, novice teachers have to start from scratch for each lesson plan. They do not have a developed pedagogical content knowldge that enables them to construct representations on the spot. Neither do they have the curriculum scripts and routines to keep a fumbling response on course in the dynamic and fluid classroom environment. This means that

they are easily derailed and find it difficult to get back on track. These difficulties can be interpreted as a limitation in their improvisational skill, since successful improvisation in teaching requires solid and easily accessible pedagogical content knowledge.

For the dialogue method to maximize its pedagogical potential, the contribution of students needs to be a substantial part of the conversation. This makes places special demands on teachers. They they should be able to make quick decisions about which answers to ignore and which to follow up. Teachers are required to listen all the time to pupils' words and understand, not just the words but also reflect upon the thought processes that produced them (Ball 1990a, 1990b, 1994). While the goals for the lesson may be clear, what the pupils will say cannot be planned. By using the dialogue method, the plans fall into the background, and teachers' knowledge structures and their ability to make decisions on the spot take center stage. When teaching more structured lessons, however, the opposite happens. The lesson plans take center stage and the knowledge base that is the foundation for improvisation fades into the background. The preparation for these two types of lessons is consequently very different (Clark and Yinger 1987).

Respect for how students think is one of the fundamentals of the dialogue method. In the teaching of math this is problematic because there are after all right answers in math. This means that in math teachers are

often not open to students' ideas. Then, on the other hand it is not always easy to understand them or the thought processes that produced them. Pupils, especially young children, use their own words and frames of reference. These are often very different from teachers' mathematical reasoning. Both Borko and Livingston (1989) and Ball (1988, 1990c) found that student teachers had very limited knowledge about students learning problems. Furthermore, Ball (1990c) found that student teachers had neither ideas about what students need to learn in mathematics, nor any ideas of what students know and can do. To use the dialogue method requires that teachers have principled mathematical knowledge and a clear idea of students' mathematical reasoning. If teachers are to use the dialogue method they must have principled mathematical knowledge and a clear idea of pupils' mathematical reasoning. It is not surprising, therefore, that student teachers derail and get lost in their math lessons.

A common thread in student teachers' plans for math lessons, is their concern for making math more fun (Ball 1990c). It is most likely their own experiences of math lead them to focus on this, together with the common view that mathematical skills are something one is born with - either you have them or you do not. If you do not, there is very little teachers can do about it. The student teachers in Ball's study considered math to be boring and difficult to learn and that this needed to be compensated for. They did

not have many ideas about how to make math more fun, but expressed the hope that they would look outside the subject matter for ideas. Often they were more concerned with making the subject matter more interesting and exciting, than worrying about the mathematical accuracy of their examples.

Method

Our informant, Marte, is in her last teaching-practice period (three weeks) during her last year in teacher training college. She was asked to be an informant because she had proved herself through participation in a different project to be reflective and ambitious to be a good teacher (Eikseth 1993, 1994, Dalen, Nilssen, Pøhmen and Nygård 1993). She is concerned with whole child development, wants the children in her class to feel that they are "successful" and have something to "contribute." Data was collected over a three week period during the spring term in 1994 when Marte was on her last teaching practice. Data collection consisted of interviews, video recordings, a detailed description of events in the lessons that were video recorded, observations, field notes and field diaries kept both by Vivi and Marte. All of the math lessons Marte taught were video recorded and later used for a reflection interview that was transcribed. Other interviews were also transcribed. This produced a total of 76 pages of transcribed text related to the teaching of math.

"Unexpected answers" is one of five analytical categories used in the data interpretation. Marte used the dialogue method in all her lessons, math, religion and social studies. The unexpected comments appear everywhere in all the subjects and all the lessons, but they led derailing only in math when introducing new concepts. This paper describes and analyses events that happened in one lesson where Marte introduced multiplication to the second graders for the first time.

Marte makes plans to teach multiplication

Vivi has made a plan for the year and Marte was in her teaching-practice period when multiplication was to be introduced. When Marte makes plans she uses the textbook, the teachers' guide and other textbooks. She has had previous experience from her earlier teaching-practice period teaching second grade math, including multiplication. She does consult return to any notes that she had made on that occasion, rather she relies on memory. They had used a different textbook and Marte chooses to make a work sheet using ideas from the textbook she had previously used. Marte is clear in her planning, she puts the child in the center. She emphasizes child-centered activity and children's experiences, and plans for a series of manipulative exercises. This is a new concept which she wants to use to stimulate the children's curiosity. She plans to gather the class of 22 children

together on a carpet in the reading corner of the classroom and demonstrate manipulative representations of multiplication. She explains:

> *I thought I could use the children and begin, for example, by asking two kids to come and stand by me to show the rest that each child has two eyes, and then they could write two plus two plus two and it is six... It is easier for them to understand when they are faced with concrete (representations), I think, and when they can use their own experiences like seeing apples in a shop and get to see it in front of them (interview 24/01, page 3).*

Marte associates manipulative exercises with the children's world of experiences, this she thinks makes it easier for them to understand and remember. Her selections fit the purpose. She starts by using natural numbers in connection with the introduction of multiplication. Later she uses well known objects, like cups and pencils to make up the sets. She justifies this by arguing the children can contribute and they get to use the eyes as well as fingers to make up the sets.

Marte's interest in getting children involved in the lesson is the reason for her choosing the dialogue method. She values the method highly and plans all her teaching in such a way that she can engage the children in a dialogue. More specifically she wants them to feel that they can make a contribution to the ideas and that they know "things." She says:

> *It is to activate the children, and try to get them involved as much as possible to reach an answer... because if they just sit there and listen to me talk, they would get bored, and I know how easy it is to start thinking about something else and everything else becomes*

more interesting. (When using the dialogue method) you have to think and concentrate and be with it all the time (video interview 21/03, page 3).

The advice Marte asks for concerns communicating with the children. She specifically asks for Vivi to comment on this aspect of her teaching after she has been teaching. She does not ask for any advice on any other aspect of teaching multiplication. She claims she feels secure with a careful lesson plan and that she is well prepared to face the unexpected. Yet, she constantly finds herself in situations where her plans do not work out.

Marte introduces multiplication

Marte introduces multiplication by reading a section from "Pippi Longstockings" a popular children's book by Astrid Lindgren. Pippi goes to school and learns about "plutification." Next, she moves on to representing multiplication employing a manipulative approach. She both uses the dialogue method and children as "manipulative objects" to represent multiplication. The class is sitting on the carpet in the reading corner. Marte picks out three children. She makes them stand up and face the rest of the class. She tells the class that they have two eyes each. Per says that it is 2+2+2, and he is asked to write that on the board. Olav raises his hand and says that it is "to times three." Marte does not realize that this is a mathematically correct answer for the problem she has represented. She tries to get him to say what she is after. Kari, at last, comes to her rescue and

says that it is "three times two." Kari is asked to write the problem on the blackboard. As Kari stands up and approaches the board, Marte says that "now we get to see how the times symbol looks like." Kari writes the numbers correctly but she writes the times symbol in the wrong place, it looks like a full stop. Afterwards when reviewing this episode on video, Marte reflects:

> *I became so unsure when she placed the symbol so low down. How am I to tackle this without hurting her? How can I get them to say that it was right, but the symbol was in the wrong place (interview 25/01, page 6) ... I expected that she would know how the symbol looked like (video interview 26/01, page 3).*

Marte's expectation makes the situation difficult. Several of the children want to correct it, but Marte says: "You can see that this is a times symbol"

Marte returns to Olav who had said "two times three." She uses pencils and children to explain "two times three." Two more children are pulled out and they get three pencils each. She explains her actions:

> *Because I said "three times two" before Olav, I have to figure out a way to tell him that it is correct, but in a different way. At this point I was conscious of picking up the thread again in what he said (video interview 26/01, page 4).*

Marte finds herself in a situation where she has to represent the communicative principle without having had the chance to think it through and plan. She does it in a way that is not appropriate: she uses different manipulative examples, and as a result ideas are not properly put into perspective. She had not planned to introduce the communicative principle at

this point, but she felt she had to then and there because of Olav's unexpected answer. As a consequence, she is derailed. She makes several attempts to get back on track. Per gives the answer she was asking for and he is asked to write his answer on the board. He does so, but puts the times symbol in the wrong place, just like Kari had done. Only after many comments from the children does Marte correct the mistakes.

Marte has the children write on the board several times and after a while it begins to look quite chaotic with numbers all over the place. She asks five new children to hold up their hands and show their fingers. She says: "Each kid has five fingers." The children answer that they have ten fingers. Marte specifies that they have five fingers on each hand, and says "5+5+5+5+..." The children keep saying that they have ten fingers each. One says 10, another 20, while two say "five times ten" and "ten times five." Marte observes herself on the video and reflects:

> *It is not surprising that I became confused...It didn't work out like I had planned, and I became extremely surprised. What in the world am I doing, this is too much...they think so differently than I do (video interview 26/01, page 5).*

Marte had not planned to go from five to fifty in five minutes. She had just wanted to start with two children. However, she was confronted with answers that she had not expected. Marte concluded this episode in the classroom by saying "when we begin to work in our books we will be using smaller numbers." She starts the class on a work sheet she has prepared.

She realizes that the children find it difficult to do the problems she has prepared for them. She discovers that there is no connection between the examples of multiplication that she had been discussing on the board and the worksheet she has prepared.

After the lesson Marte feels that the children were restless and confused. After observing them doing the problems on the work sheets, she realizes they have not understood. She comments:

> *I thought the kids would see that each kid was a set and that you should count kids to get the set. It is clear that if I had shown it on the board, we could have counted together more, and written it down (video interview 26/01, page 4).*

Marte's first reflection over this incident is that she was trying to do too much all at once. She decided to repeat the lesson the following day. This time she read Høines' (1987) book about teaching math to young children. It was required reading for her math methods class which she took during her first year of teacher education. This time she uses only one set for manipulate exercices. She does not abandon the dialogue, but writes the problems herself on the board. Now there is a connection between what they go through on the board and their worksheets.

Discussion

There are several positive aspects to Marte's teaching. She wants the children to develop a positive self-concept, the activities she plans are child-

centered, and she wants each and every child to feel that they can make a positive contribution during the lesson. This child-centered educational philosophy is also the source of her problems. Marte does not have the knowledge base, especially pedagogical content knowledge in math, to transform children's clumsy comments into something more substantial. She follows the children's comments without transforming them. She finds herself hopelessly lost and abandons the introduction of multiplication and sends the children to their seats to work on worksheets that they do not understand. Marte is reflective, one of many positive qualities that makes her such a promising young teacher. She realizes that she did not achieve what she had set out to do and the whole lesson was confused. Marte's planning for teaching math has many parallels especially among her American colleagues (Ball 1988, Borko and Livingston 1989). They think that math is boring and difficult. That is why it is important to make it interesting and exciting for the children. They try to do this by adding elements that have little or no connection with mathematical understanding. Yet, at the same time they want to help the children see how useful and relevant math is in their daily lives. We see some of the same issues in Marte's lesson plans. She starts by reading about "Pippi," a well known literary character. The concept is introduced via "sets", and she uses the children themselves in manipulative exercises. It is a mathematically correct

choice. Her rationale, however, has nothing to do with mathematical correctness. She claims she uses children to make multiplication interesting and to make them active participants in the lesson, which is in tune with the child-centered educational principles she reads about in the official guidelines for primary education and with the tenets of her teacher education.

Finding the ideal world of theory in the complex world of the classroom is, however, a recurring problem for student teachers the world over. Student teachers expect to be able to apply theoretical concepts and that teacher education can give "recipes" for teaching different mathematical ideas. In Marte's case we see her vague ideas of how important it is to engage children and the role of representing new ideas through manipulative exercises. This is something she has learned in her teacher education, but as we have seen, she is somewhat unsure of how to put these ideas into practice. Her attempts at activation and manipulation become an "illustration" for most of the kids. She has only asked three children to stand up. They stand with their backs to the board. They have no other task. This creates unrest both among the children standing and those watching. Marte has to cope with this unrest as well as getting them to understand a complicated mathematical concept. She has made an already complex situation more complicated. Classrooms are already complex with their multidimensionality, simultaneity and unpredictability (Doyle 1977). For

Marte it becomes even more unpredictable when the children do not write their answer as she had expected when she made her plans.

Not only is the situation unpredictable for Marte, she is also struggling with other concerns. She has a mathematical idea to communicate, and she wants the children to feel successful and that they have something to contribute. This last concern is the reason why she selected the teaching method. The dialogue method is interactive (Yinger 1987). In such a teaching situation experienced teachers play upon the "unexpected." The plan is developed as a guideline to make sure that the activity is on track while at the same time opening for responses from the children. Marte's plans are different. She has a clear plan for the lesson, but only for herself. Her plan includes using the dialogue method, which in theory builds on what the children already know. Yet she is surprised when she realizes that the children think differently than she does. She has very little practical insight into children's thinking which is the very foundation for the dialogue method. And when the children do not answer as she has expected them to do, she still tries to follow up on their answers and thus ends up derailing her plans. The fact that student teachers, like Marte, do not have well developed schema in important areas makes it difficult to plan a flexible and interactive situation, which is neccessar when the dialogue method is used in the classroom. It requires solid pedagogical content knowledge in math, also

including knowledge about how second graders think mathematically and the kinds of mistakes they make.

Experienced teachers know what answers can potentially make a contribution to all the children's mathematical understanding. They systematically weed out answers which are off "target". They make such distinctions on the spot, all the time. Marte is fixed on the individual child, like a spotlight on a darkened scene. The interests of the rest of the children are ignored. When Kari places the times symbol in the wrong place she does not correct it because she does not want Kari to fail in front of the class, and the same applies to her response to Olav. Marte's concerns with Kari's and Olav's feelings override the interests of the rest of the class. Marte later demonstrates that two times three gives the same answer as three times two. She has to demonstrate the communicative principle on the spot. Marte manages to demonstrate with a manipulative two times three representation, but this representation is not suitable for showing the connection to three times two, which is what she wanted to do.

Marte has learned a great deal after such in-depth reflections on her teaching with her teaching practice tutor (Vivi). She is a promising young teacher because she reflects upon her mistakes and is willing to try again the next day, starting from scratch. At the same time she studies how children think mathematically in a text book from her math method class during the

first year of teacher education. The next day we see that Marte reduces the complexity of the classroom by not including children as much in her representations. She selects other manipulative activities and writes on the board herself. This makes the lesson more structured and orderly, and she maintains control over what is going on. She still employs the dialogue method because it means so much to her pedagogical philosophy. Yet, she experiences unexpected incidents, but that is another story.

Implication for teacher education

It is very difficult for student teachers to have developed the kind of pedagogical content knowledge in math to be able to teach math to young children using interactive methods. Student teachers, even promising young teachers like Marte, run into difficulties when trying out the dialogue method in the teaching of math. They experience failure and most give up. Those who give up often return to traditional methods "talk'n chalk" and dare not stry too far from the textbook. The case study of Marte shows us, however, if certain aspects of the dialogue method are modified, such as reducing complexity, it becomes slightly more user-friendly for novices. But, student teachers need on the spot advice and guidance to develop such complexity-reducing strategies, because each situation is unique.

Marte was only two months away from graduation when she taught second graders multiplication. In August she will be in charge of her own class teaching all subjects. As we have seen from this case study, Marte has a lot to learn. With the current practice (in all Western countries), she will be left on her own to develop professionally. She has to face her first year in teaching alone, which will probably be the most critical year in her entire career (Bullough 1989). The experiences during that first year make or breake teachers, often they are decisive factor in influencing what kind of teacher they develop into (Grossman 1990). A mentor system is badly needed. We have invested time and material resources in our student teachers and they too have invested both time and money in their education. We must not leave them to decide when to ask for help, because experience has shown that most novice teachers do not (Gudmundsdottir 1995). Teacher education must not end when student teachers leave college. It must be followed by supervised practice, at least through the first year.

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